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Compositional analysis of resurrection bush plant (*Myrothamnus flabellifolius*) and its potential mode of action in broilers

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Antibiotic feed additives are added to broiler diets at subtherapeutic dosages to boost feed conversion, accelerate growth and improve meat yield. However antibiotic growth promoters have fostered the emergence and spread of antibiotic resistant genes which has led to their ban and has raised public concern regarding the dissemination of antibiotic resistant pathogens and their implications for food safety and human health. *Myrothamnus flabellifolius* plant native to Southern Africa known to survive extreme desiccation has rich bioactive compounds and carbohydrate profile that can potentially affect broiler performance, health and meat quality. In this narrative review the literature search was designed to encompass parameters related to *M. flabellifolius* plant nutritional and phytochemical composition and how the mode of action of the compounds affects broiler growth performance, health and meat quality. *M. flabellifolius* contains carbohydrate trehalose, raffinose, stachyose and sucrose which act as prebiotics and energy sources when included in broiler diets as a feed additive. Phytochemical composition of resurrection bush plant, which is rich in phenolic, flavonoid and other bioactive compounds improves broiler gut health, immunity, reduces oxidative stress and improves broiler meat quality and shelf life. Understanding the preliminary chemical and phytochemical composition of *M. flabellifolius* and its perceived mode of action and relating that to broiler performance and meat quality is essential and form the basis for the formulation of diets that enhance broiler welfare and product safety. Future research should prioritize *in vivo* investigations to gain more comprehensive insights into the interactions among these dietary components and identify the optimal combinations for broiler feeding strategies.

KEYWORDS

broiler diets, *M. flabellifolius*, nutritional composition, perceived mode of action, phytochemical composition

1 Introduction

The resurrection plant *Myrothamnus flabellifolius*, known for its remarkable ability to survive extreme desiccation, offers valuable insights in the field of animal nutrition (Tebele et al., 2025). Composition of *M. flabellifolius* shows a rich beneficial phytochemical and nutrient profile suggesting its potential as a feed additive to improve broiler performance and meat quality (Nantapo and Marume, 2022). Its chemical composition has garnered attention due to its array of bioactive compounds, including polyphenols and flavonoids,

which possess antioxidant properties that can potentially impact poultry health and meat characteristics (Erhabor et al., 2020) in this wake of antimicrobial resistance and ban on antibiotic feed additives (Nhara et al., 2025). *Myrothamnus flabellifolius* contains a diversity of secondary metabolites, such as xanthenes and flavanones, that contribute to its nutritional and medicinal qualities. These compounds have been linked to various health benefits, including protection against oxidative stress, which is particularly relevant in poultry production where oxidative damage can compromise meat quality (Chukwuma et al., 2019; Nantapo and Marume, 2022). Enhancing the antioxidant capacity in broilers through dietary supplementation with such plant extracts can mitigate oxidative challenges during meat processing and storage, improving overall meat quality (Delles et al., 2014). Moreover, the incorporation of *M. flabellifolius* as a phytogetic feed additive in broiler diets has the potential to improve growth performance (Ren et al., 2025). Dietary inclusions of the resurrection plant can influence key performance metrics in broilers, such as weight gain and feed conversion ratio (Nantapo and Marume, 2022) and these factors are crucial in the poultry industry as they directly relate to economic viability and product quality. The antioxidative properties inherent in *M. flabellifolius* could also play a pivotal role in mitigating the adverse effects of heat stress commonly faced by broiler chickens (Hu et al., 2019). Heat stress significantly affects meat quality by altering pH levels, increasing drip loss, and influencing texture (Sugiharto, 2022; Jing et al., 2024). Applications of *M. flabellifolius* in animal nutrition are still largely theoretically based on known properties of its individual components (Nantapo and Marume, 2022). Incorporating plant-derived antioxidants like those found in *M. flabellifolius* could help counteract these detrimental effects, potentially leading to improved meat tenderness and juiciness (Chen et al., 2023). As such, strategically using this plant in poultry diets could promote animal welfare and enhance the quality of poultry products. By leveraging the bioactive compounds present in *M. flabellifolius*, poultry nutritionists may formulate feeds that may support growth and enhance the sensory attributes of the meat (Nantapo and Marume, 2022). The chemical composition of *M. flabellifolius* represents a promising avenue for improving broiler performance and meat quality. Its rich antioxidant profile can alleviate oxidative stress in poultry, directly affecting growth parameters and meat characteristics. This narrative review focuses on preliminary phytochemical and nutritional composition analysis of *M. flabellifolius* and its potential as a feed additive in broiler diets.

2 Materials and methods

2.1 Literature search strategy

A narrative literature review was conducted to synthesize existing knowledge on “*M. flabellifolius*” and its potential application in broiler production. Relevant peer-reviewed literature published between 2000 and 2026 was systematically retrieved from four established academic databases Web of Science, Google Scholar, Scopus, and PubMed. The search terms employed included “*M. flabellifolius*,” “chemical composition,” “phytochemical composition,” “bioactive compounds,”

“phytogetic feed additives,” “broiler performance,” and “meat quality,” used individually and in combination using Boolean operators (AND, OR).

2.2 Eligibility and inclusion criteria

To ensure methodological transparency and consistency in the selection of literature, predefined eligibility criteria were established prior to the review process. Studies were considered eligible for inclusion if they met one or more of the following conditions, reported on the nutritional and/or phytochemical composition of *M. flabellifolius*, investigated the biological and pharmacological properties of bioactive compounds identified in “*M. flabellifolius*” and examined the effects of phytochemical compounds not exclusively from “*M. flabellifolius*” but also from other phytogetic plant sources on broiler chicken performance and meat quality, where such compounds are chemically analogous or pharmacologically relevant to those found in *M. flabellifolius*.

2.3 Exclusion criteria

Studies were excluded if they were published outside the 2000–2026 timeframe, were not peer-reviewed, were duplicated across databases, or lacked sufficient methodological detail to allow meaningful interpretation of findings. Conference abstracts, grey literature, and non-English publications were also excluded to maintain the scientific rigor of the review.

2.4 Data extraction and synthesis

The database search, titles and abstracts of retrieved articles were screened for relevance against the defined eligibility criteria. Full texts of potentially eligible articles were subsequently retrieved and evaluated in detail. Data were extracted on key themes, including the phytochemical profile of “*M. flabellifolius*”, the perceived modes of action of its constituent bioactive compounds, and the documented or inferred effects of analogous phytochemicals on broiler performance parameters and meat quality attributes. Given the heterogeneity in study designs, plant species investigated, and outcome measures reported across the included literature, a qualitative narrative synthesis was deemed the most appropriate approach rather than a formal meta-analysis.

3 *Myrothamnus flabellifolius* chemical and phytochemical composition

Myrothamnus flabellifolius chemical composition reveals a rich variety of secondary metabolite (Nako, 2014). The ability of *M. flabellifolius* to withstand extreme dehydration is also linked to its metabolic processes, wherein high levels of trehalose have been identified (Deeba and Pandey, 2017). Trehalose serves as an osmoprotectant and is crucial for cellular stability during desiccation (Kosar et al., 2019). This sugar not only aids in water retention but also contributes to the stabilization of proteins and membranes during the drying phases, allowing for survival in harsh conditions (Delorge et al., 2015). Moreover, the accumulation of specific polysaccharides, including arabinan, highlights the adaptive

TABLE 1 Nutritional and phytochemical composition of *Myrothamnus flabellifolius* bush tree.

Carbohydrate	Quantity	References
Trehalose	34.7g/mmg ₁	Nantapo and Marume (2022)
Raffinose	2.49g/100 g	Chukwuma et al. (2019)
Stachyose	2.18g/100 g	Chukwuma et al. (2019)
Sucrose	56.5g/mmg ₁	Nantapo and Marume (2022)
Phytochemical	Quantity	References
Gallic acid	26.62%	Chukwuma et al. (2019)
Ferulic acid	15.23%	Chukwuma et al. (2019)
Gallocetechin	1.43 ± 0.03 mg/g	Nantapo and Marume (2022)
Trans pinocarveol	19.57%	Nantapo and Marume (2022)
Quercetin glucose	3mgAWE	Nantapo and Marume (2022)
Pinocerveol	11.13%	Nantapo and Marume (2022)

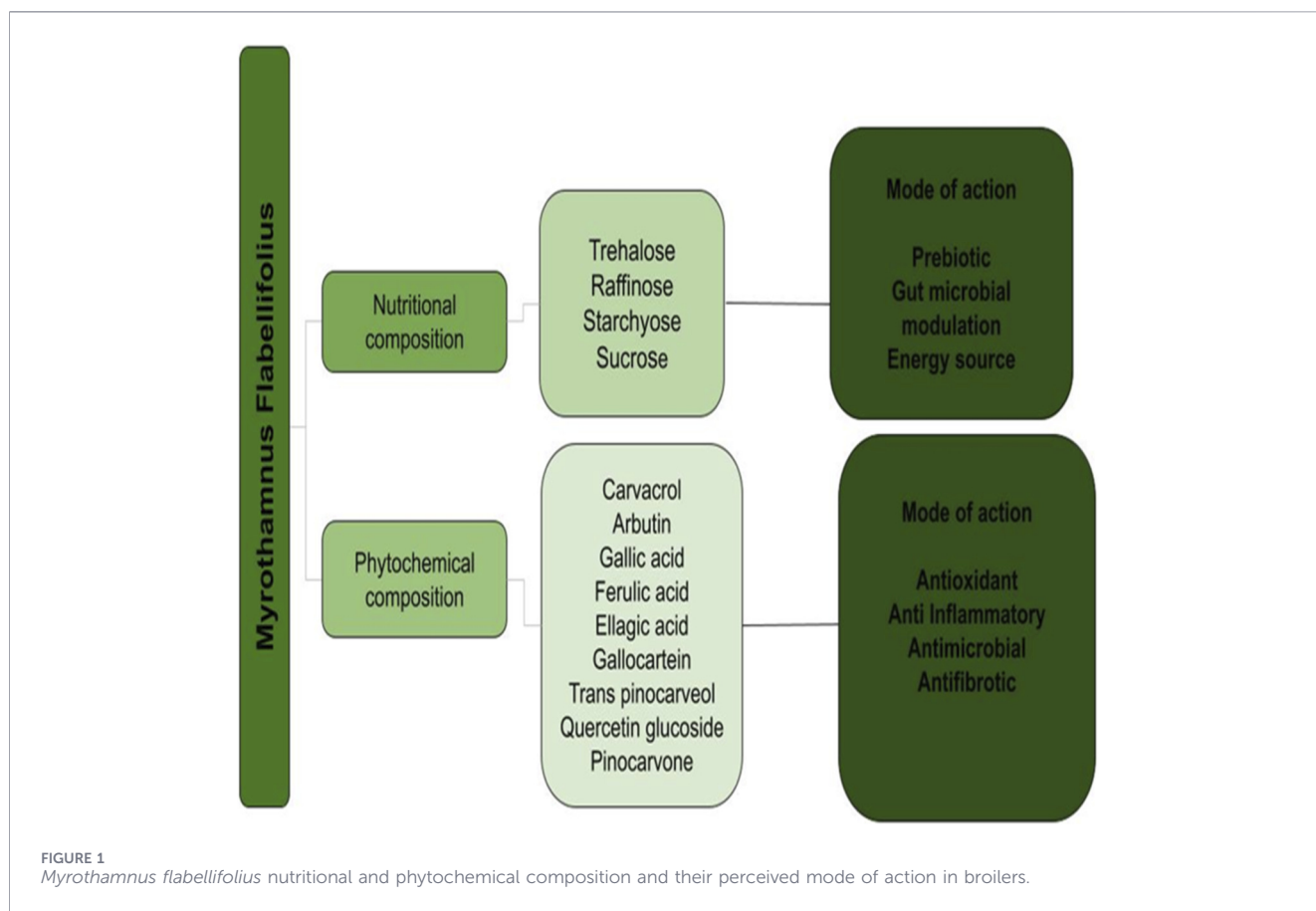
mechanisms in *M. flabellifolius* that facilitate its resilience to environmental stress (Gall et al., 2015). These osmoprotectants function together to maintain cellular integrity during desiccation, enhancing the plant's survival and recovery capabilities upon rehydration (Neeragunda Shivaraj et al., 2018). *Myrothamnus flabellifolius* presents a complex biochemical landscape that underpins its unique survival strategies in arid environments (Marks et al., 2022). Significant phytochemical components include various flavonoids, tannins, and phenolic acids that contribute to the plant's antioxidant properties (Matotoka and Masoko, 2024). The total phenolic content in *M. flabellifolius* has been quantified at levels around 82.26 ± 5.30 mg/g GAE, indicating a robust capacity to mitigate oxidative injury to cells (Chukwuma et al., 2019). Additionally, there are reports of gallic acid and chlorogenic acids being present in the extracts from *M. flabellifolius*, further emphasizing its potential as a natural antioxidant source (Kwape et al., 2016). These compounds are vital in offering protection against oxidative stress, a common pathway for cellular damage in biological systems (Erhabor et al., 2020).

The resurrection plant is characterized not only by its unique chemical composition but also by its biological activities. The essential oils extracted from *M. flabellifolius* exhibit both antibacterial and antifungal activities, underscoring its potential applications in both traditional and modern medicine (Matotoka and Masoko, 2024). The presence of these bioactive compounds can be beneficial in treating infections and could assist in formulating natural antimicrobial agents. Furthermore, *M. flabellifolius* has shown promise in ethnomedical applications, particularly in the treatment of a broad range of ailments, such as respiratory issues, inflammation, and various skin conditions (Nantapo and Marume, 2022). Its phytochemical constituents not only bestow health benefits attributed to traditional medicinal practices but also reflect the plant's evolutionary adaptations to environmental stresses (Gechev et al., 2014). Notably, sucrose is the most abundant carbohydrate at 56.5 g/mmg⁻¹, followed by trehalose at 34.7 g/mmg⁻¹, while raffinose (2.49 g/100 g) and stachyose (2.18 g/

100 g) are present in comparatively smaller quantities. The dominance of sucrose and trehalose is consistent with the plant's desiccation-tolerance mechanisms, where these sugars serve as osmoprotectants (Kosar et al., 2019; Deeba and Pandey, 2017). The relatively lower concentrations of raffinose and stachyose, however, do not diminish their prebiotic significance, as these oligosaccharides exert functional effects at modest dietary levels (Zhu et al., 2020; 2021). Table 1 summarizes the nutritional and phytochemical composition of *M. flabellifolius* bush tree.

3.1 Summary of nutritional and phytochemical composition of *M. flabellifolius* and perceived mode of action in broilers

Figure 1 below summarizes the *M. flabellifolius* nutritional and phytochemical composition and their perceived mode of action in broilers. *M. flabellifolius* nutritional and phytochemical composition includes a variety of polysaccharides, amino acids, vitamins and bioactive compounds such as flavonoids, polyphenols, and tannins and by extension from related flavonoid research presence of these compounds can potentially have prebiotic, gut modulation, anti-inflammatory, antimicrobial and antifibrotic effect when included in broiler diets (Plamada and Vodnar, 2021; Nantapo and Marume, 2022; Yuan et al., 2023; Jubair et al., 2025). Several studies reveal that analogous compounds from other phytochemical sources suggest that those in *M. flabellifolius* exhibit potent antioxidant, antimicrobial, anti-inflammatory properties (Nhara et al., 2025). Presence of polysaccharides especially non starch carbohydrates have prebiotic effect which can influence performance when included in broiler diets (Nantapo and Marume, 2022). Polysaccharides in resurrection bush serves as an energy source that boots the population of beneficial bacteria in the duodenum and ileum creating a more competitive intestinal environment (Duangnumswang, 2023; Kuleile, 2024). An increase in *Lactobacilli* bacterial species helps reduce the ability of pathogenic bacteria from colonising the gut (Rehman et al., 2009; Hernández-Hernández et al., 2012; Ducarmon et al., 2019) and they also reduce inflammatory damage in the caecum, downregulate proinflammatory cytokine genes and increase anti-inflammatory cytokine gene (Hernández-Hernández et al., 2012; Jiang et al., 2019; Oluseyifunmi and Olukosi, 2026). The phytochemical profile of *M. flabellifolius* not only contributes to its adaptive survival in arid conditions but also translates to nutritional benefits which when included in broiler diets are perceived to promote growth performance and health stability (Nantapo and Marume, 2022; Sumadja et al., 2025). Phytochemical compounds in general have been shown to stimulate digestive enzyme production and improve feed conversion ratios (Windisch et al., 2008; Al-Massad et al., 2018), leading to enhanced growth performance in broilers. The presence of antioxidants and antimicrobial compounds helps to enhance the gut environment, thereby promoting better nutrient absorption and utilization, which can reflect in body weight gain and feed conversion efficiency (Kumanda et al., 2019). By maintaining a healthy intestinal microbiota, these phytochemicals can mitigate pathogenic



challenges often encountered in modern poultry production systems.

3.1.1 Trehalose its effect on broiler performance

Trehalose, a non-reducing disaccharide, has gained attention as a potential dietary supplement in broiler nutrition due to its promising effects on growth performance and meat quality. Trehalose can mitigate protein aggregation by stimulating cellular autophagy, suppress hepatic inflammatory cascade and enhancing energy metabolism (Sooksridang et al., 2024). Supplementation with trehalose has been shown to enhance intestinal morphology in broiler chickens, which contributes to better nutrient absorption and overall performance without the use of antibiotics. Additionally, trehalose supplementation may also modulate inflammation and improve gut microbiota composition, further supporting growth performance (Ruangpanit et al., 2020; Wu et al., 2020). In terms of growth performance, studies demonstrate that trehalose supplementation can improve feed conversion ratios (FCR) and average daily gain (ADG) in broilers. Specifically, one study indicated that diets containing 0.5% trehalose resulted in significant improvements in growth metrics compared to control groups (Ruangpanit et al., 2020; Fan et al., 2023). Beyond growth promotion, trehalose has been associated with improvements in meat quality in broilers. The quality of poultry meat encompasses various aspects, including texture, juiciness, and oxidative stability (Mir et al., 2017; Sugiharto, 2022). Incorporating trehalose into diets is believed to reduce thawing loss in frozen meat, thereby enhancing

sensory attributes such as smell and texture. Improvements in oxidative stability attributed to trehalose may also extend shelf life and elevate overall meat quality during storage (Xu et al., 2022).

The complexity of meat quality is reflected in several quantifiable attributes, including pH, water holding capacity, and sensory characteristics, all essential for industry standards and consumer satisfaction (Mir et al., 2017; Štastník et al., 2019). Enhanced properties from trehalose supplementation can improve muscle integrity and minimize adverse effects related to oxidative stress, offering clear advantages for producers seeking to enhance meat quality (Delles et al., 2014; Xu et al., 2022).

Supplementation of broilers with trehalose that can be sourced from *M. flabellifolius* plant as a feed additive might have a significant potential for enhancing both broiler performance metrics and meat quality. Its benefits might arise from improvements in gut health, growth performance, and the qualitative aspects of poultry meat. Table 2 below summarizes the performance response of broiler chickens to trehalose inclusion *in vivo*.

3.1.2 Raffinose and its potential effect on broiler performance

Raffinose in broiler diets has become an area of significant inquiry given its potential to enhance both broiler performance and meat quality. It is a type of oligosaccharide predominantly found in legumes and some vegetables (Kanwal et al., 2023), has been implicated in improving growth metrics and enhancing meat characteristics due to its role in modulating gut microbiota and

TABLE 2 Effects of trehalose inclusion in broiler chickens' diets on performance and meat quality.

Trehalose dose	Effect	References
0.5% dietary trehalose	Improved feed conversion ratio (FCR) and average daily gain (ADG) vs. control; enhanced intestinal morphology (increased villus height); modulated gut microbiota composition	Ruangpanit et al. (2020)
0.5% dietary trehalose	Reduced <i>Campylobacter jejuni</i> and <i>Clostridium perfringens</i> colonisation in the intestine; antimicrobial benefit without antibiotics	Fan et al. (2023)
0.3% and 0.5% dietary trehalose	Improved growth performance and intestinal morphology at high stocking density; reduced footpad dermatitis score; maintained gut bacterial balance	Sooksridang et al. (2024)
0.5% dietary trehalose	Modulated inflammatory cytokine expression; reduced intestinal inflammation in <i>Salmonella</i> Typhimurium-challenged broilers; improved microbiota diversity	Wu et al. (2020)
Topical/dietary trehalose (myofibrillar protein interaction)	Reduced thawing loss in frozen broiler meat; improved water-holding capacity, texture, and sensory attributes (smell, juiciness) during storage	Xu et al. (2022)
Trehalose supplementation (variable doses)	Suppressed hepatic inflammatory cascade; enhanced energy metabolism; mitigated protein aggregation via stimulation of cellular autophagy	Sooksridang et al. (2024)

ADG, average daily gain; FCR, feed conversion ratio; SOD, superoxide dismutase; WHC, water-holding capacity; MDA, malondialdehyde.

fermentation processes within the gastrointestinal tract (Zhu et al., 2020).

Recent studies have underscored the positive impacts of oligosaccharides, including raffinose, on broiler growth performance. Specifically, research suggests that these oligosaccharides can foster a favorable gut environment that enhances nutrient absorption, ultimately leading to improvements in average daily gain (ADG) and feed conversion ratio (FCR) (Zhu et al., 2020; 2021). The application of raffinose not only aids nutrient digestibility but also contributes to gut health by influencing the composition of the cecal microbiota, which can affect the overall health and performance of broilers during the critical growth phases (Zhu et al., 2020).

The presence of raffinose and similar oligosaccharides has been linked to improved meat quality traits including water holding capacity (WHC), pH, and meat texture (Mir et al., 2017; Choi et al., 2023). Furthermore, the ability of these oligosaccharides to promote beneficial microbiota may mitigate oxidative stress, a condition that can detrimentally impact meat quality (Zhang et al., 2022; Lan et al., 2024). Studies indicate that dietary interventions, such as the addition of antioxidants alongside oligosaccharides, can further optimize the sensory characteristics of meat, including flavor and texture, which are critical parameters for consumer acceptance (Delles et al., 2014; Yang et al., 2025). The modulation of gut microbiota, improvement in nutrient absorption, and enhancement of meat sensory characteristics are among the significant benefits attributed to this oligosaccharide (Kanwal et al., 2023). Incorporation of *M. flabellifolius* raffinose-based feed additives into broiler diets can be of considerable promise for enhancing both growth performance and meat quality.

3.1.3 Stachyose and its potential effect on broiler performance

In poultry nutrition, stachyose, a type of oligosaccharide, functions primarily as a prebiotic, promoting the growth of beneficial gut microbiota, particularly *Lactobacillus species*, which

aids in fermentation processes and enhances nutrient absorption and utilization (Zhu et al., 2021). The inclusion of stachyose in broiler diets leads to increased fermentation activity in the ceca, resulting in higher levels of volatile fatty acids, such as acetate and propionate, which are critical for optimal growth performance in broilers (Zhu et al., 2020). There have been reported significant improvements in growth metrics and nutrient digestibility with the incorporation of stachyose into broiler diets, underscoring its role in enhancing productive efficiency (Liu et al., 2020). Moreover, the advantages of dietary stachyose extend to meat quality attributes (Yang et al., 2025). The metabolic interactions facilitated by stachyose likely influence muscle development, including factors such as color, tenderness, and overall palatability. Improved gut health and nutrient absorption translate directly into superior meat quality characteristics (Geay et al., 2001). The enhancement of volatile fatty acid production by gut fermentation can lead to improved flavor and juiciness in the meat, both of which are significant to consumers (Liu et al., 2020). Furthermore, the modulation of the microbial community in the gut may lead to reduced production of undesirable metabolites such as skatole, which can negatively impact meat aroma and flavor (Liu et al., 2020; Wang M. et al., 2022; Xu et al., 2024).

Previous research indicated that dietary antioxidant supplementation enhances oxidative stability in poultry meat, a critical quality trait (Delles et al., 2014). Although specific studies focused on the synergistic effects of stachyose with antioxidants have not been extensively available, the implications of nutritional strategies that combine these components suggest a promising avenue for enhancing meat quality in broilers through well-formulated diets (Delles et al., 2014). The integration of stachyose into broiler diets not only facilitates improved growth performance through enhanced nutrient absorption and gut health but also positively affects the quality attributes of the meat. Table 3 summarizes the performance responses of broiler chickens to raffinose and stachyose (soybean oligosaccharides) as analogous compounds also present in *M. flabellifolius*.

TABLE 3 Effects of raffinose and stachyose (soybean oligosaccharides) inclusion in broiler chickens' diets on performance and meat quality.

Compound and dose	Effect	References
2 and 4 g/kg raffinose (soybean oligosaccharide fraction)	Improved ADG and FCR in broilers; enhanced cecal microbiota composition (increased <i>Lactobacillus</i> , reduced <i>Clostridium</i>); improved nutrient digestibility	Zhu et al. (2020)
2 and 4 g/kg raffinose	Enhanced cecal microbial diversity; increased production of short-chain fatty acids (acetate, propionate, butyrate); reduced cecal ammonia and skatole concentrations	Zhu et al. (2020)
2 and 4 g/kg stachyose	Improved ADG and FCR vs. control; increased cecal fermentation activity; elevated total SCFA and acetic acid concentrations; promoted <i>Lactobacillus</i> proliferation	Zhu et al. (2021)
4 g/kg stachyose	Reduced skatole concentration in cecal digesta; downregulated hepatic CYP2E1 mRNA expression; improved meat aroma profile and reduced off-flavour risk	Liu et al. (2020)
2 g/kg raffinose +2 g/kg stachyose (combined)	Synergistic prebiotic effect; superior improvement in cecal microbiota balance and SCFA production vs. individual oligosaccharides alone	Zhu et al. (2021)
Oligosaccharide supplementation (raffinose-type)	Improved water-holding capacity (WHC) and meat pH; enhanced meat texture scores; reduced drip loss; improved overall sensory quality in breast muscle	Choi et al. (2023)

SCFA, short-chain fatty acids; ADG, average daily gain; FCR, feed conversion ratio; WHC, water-holding capacity; CYP2E1 = cytochrome P450 2E1 enzyme involved in skatole metabolism.

3.1.4 Sucrose and its potential effect on broiler performance

Recent studies have indicated that dietary sucrose can yield varying effects on growth metrics and the overall health of broilers (Hussein et al., 2016). The contradictory findings in the literature likely reflect dose-dependent and context-dependent effects of dietary sucrose. Al-Rabadi et al. (2018) reported reduced feed intake and ADG when sucrose was combined with excess lysine during the growing phase, suggesting that the adverse effects may be attributable to amino acid–carbohydrate interactions and altered gut morphology rather than sucrose *per se*. In contrast, the microbiome-modulating effects described by Rehman et al. (2008) occurred under different dietary and experimental conditions. These discrepancies underscore the importance of carefully calibrating sucrose inclusion levels and dietary matrix composition before any recommendation for its use as a functional ingredient can be made.

Carbohydrate sources, including sucrose, revealed insights into their impacts on microbial fermentation and digestive health (Deehan et al., 2017). Diets enriched with sucrose can modify microbial fermentation profiles, enhance the production of beneficial short-chain fatty acids while reduce harmful byproducts, such as ammonia (Rehman et al., 2008). These changes could, in turn, improve gut health and nutrient absorption, crucial for optimizing broiler performance. Additionally, the modulation of gut microbiota through dietary sucrose reflects a complex relationship between carbohydrate sources and broiler intestinal health, influencing performance and meat quality (Ali et al., 2022; Zhu et al., 2022). Dietary factors, including carbohydrate sources and composition, directly influence the sensory attributes of broiler meat, such as tenderness, juiciness, and flavor (Mir et al., 2017). The presence of sucrose might not only affect growth rates but also modify the fatty acid profile and overall meat quality parameters in poultry, which are essential for consumer acceptance (Luo et al., 2022). Enhancements in meat quality can also be influenced by dietary energy profiles; therefore, studies examining different carbohydrate sources found that sucrose presented potential benefits, with consideration of energy balance required (Gutyj et al., 2017).

Furthermore, an important consideration regarding sucrose in broiler diets is its role during stress conditions. The research by Virden and Kidd, 2009 explored the physiological adaptations in broilers when sucrose is supplemented in conjunction with electrolytes under stress, establishing a therapeutic potential for plant-derived sugars in alleviating stress responses (Sun et al., 2019). Sucrose offers promise for modulating growth performance and meat quality in broilers; its supplementation must be carefully calibrated alongside dietary compositions and energy sources to avoid adverse effects on broiler growth metrics.

3.1.5 Gallic and its potential effect on broiler performance

Gallic acid, a naturally occurring phenolic compound (Nantapo and Marume, 2022), and has potential to enhance broiler performance and meat quality. Research indicates that incorporating gallic acid into broiler diets may lead to improvements in growth metrics and the overall quality of meat produced (Jung et al., 2010; Samuel et al., 2017; Xiong et al., 2024). Supplementation of gallic acid has been associated with marked improvements in broiler growth performance. In terms of meat quality, the effects of gallic acid are similarly noteworthy. Its antioxidant properties play a crucial role in enhancing the oxidative stability of broiler meat. Diets supplemented with gallic acid significantly elevated the radical scavenging activity of broiler breast meat compared to control groups (Arshad et al., 2013; 2017). The increased antioxidant capacity not only improves the shelf life of the meat but also enhances sensory attributes, such as flavor and juiciness. Altering dietary components, including the addition of nutrient-rich oils and other supplements, can modify the fatty acid composition of broiler meat, potentially enhancing its health attributes (Nhara et al., 2024). The incorporation of gallic acid, known for its ability to neutralize free radicals, thus becomes an important strategy for optimizing the fatty acid profile, leading to healthier meat products that are lower in saturated fats and enriched with beneficial polyunsaturated fatty acids (PUFAs) (Bešlo et al., 2023). Table 4 summarizes the effects of gallic acid inclusion in

broiler chicken diets and its potential effect on performance and meat quality.

3.1.6 Ferulic acid and its potential effect on broiler performance

Ferulic acid, a naturally occurring phenolic compound, has elicited considerable interest in the field of animal nutrition, particularly in broiler production (Zheng et al., 2024). This interest stems from its potential to improve growth performance, enhance immune function, and optimize meat quality in broilers. The relevance of ferulic acid in poultry diets is underscored by its various biochemical properties, including antioxidant, antibacterial, and anti-inflammatory effects, which are crucial in mitigating stressors that affect broiler health and meat quality. According to Table 1 above *M. flabellifolius* contains an average of 15.23% ferulic acid and supplementation of ferulic acid from other sources has led to improved growth performance by positively influencing feed conversion ratios (Yi et al., 2025). On a physiological level, ferulic acid contributes to the maintenance of gut health, which is essential for optimal nutrition absorption and overall animal wellbeing. Ferulic acid inclusion in broiler diets can instigate favorable alterations in intestinal microbiota, enhancing gut health and immune function (Shu et al., 2022). Furthermore, the modulation of gut microbiota can reduce the presence of harmful bacteria such as *Campylobacter* spp., supporting the assumption that ferulic acid's antibacterial properties can lead to healthier broiler production without the need for extensive antibiotic use (Lassen et al., 2022). Moreover, the antioxidant properties of ferulic acid play a significant role in meat quality enhancement (Zhang et al., 2025). Antioxidants stabilize free radicals and prevent oxidative stress, which can lead to detrimental effects on meat quality, including increased lipid peroxidation and off flavor's (González-Ríos et al., 2016). The addition of ferulic acid in poultry diets has been shown to

improve the oxidative stability of meat, thereby preserving its quality during storage and enhancing sensory attributes such as flavor and juiciness (Bou et al., 2009). This is particularly pertinent when considering the role of *postmortem* glycolysis and pH regulation in meat quality. Elevated pH levels help prevent the formation of pale, soft, and exudative (PSE) meat, which is characterized by a pH decrease below 5.8 (Sugiharto, 2022). As the poultry industry continues to face challenges related to meat quality and disease control, ferulic acid emerges as a promising additive that may contribute to both improved animal health and product quality (Zheng et al., 2024). Table 5 summarizes the effects of ferulic acid inclusion in broiler chickens' diets on performance and meat quality.

3.1.7 Gallic acid and its potential effect on broiler performance

Gallic acid, a type of flavonoid found in various plants including *M. flabellifolius* plant, aligns with findings that emphasize the positive impacts of polyphenols and flavonoids on poultry health and productivity (Abd El-Hack et al., 2025). Research indicates that dietary supplementation with flavonoids can enhance growth rates, improve feed conversion ratios (FCR), and positively impact meat quality attributes such as tenderness and oxidative stability (Shakeri et al., 2020; Cao et al., 2022). Dietary polyphenols, like gallic acid, mitigate the effects of oxidative stress, particularly in heat stress conditions, which are prevalent in poultry farming. Heat stress has been shown to compromise both growth performance and meat quality by altering lipid and protein metabolism, leading to increased oxidative damage (Shakeri et al., 2020; Shakeri and Le, 2022). Supplements such as polyphenols can counteract these adverse effects, boosting antioxidant activity within the birds and thus improving meat quality (Shakeri et al., 2020). Gallic acid may enhance the nutritional profile of the meat

TABLE 4 Summarizes the effects of gallic acid inclusion in broiler diets on performance.

Gallic acid dose	Effect	References
100 mg/kg	Reduced MDA in plasma by day 42 increased total antioxidant capacity	Samuel et al. (2017)
≥100 mg/kg	Increased breast muscle ratio by day 42	Samuel et al. (2017)
1.0% mixture of gallic acid and linoleic acid	Increased feed efficiency Increased DPPH radical scavenging activity TBARS and total phenolic content in breast muscle improved	Jung et al. (2010)
0.02,0.04% and 0.06% inclusion in broiler diets	Increased body weight gain, feed intake, nutrient digestibility and energy Dietary inclusion of gallic acid had no effect on meat quality	Biswas et al. (2023)
5 g/kg gallic acid in feed	Increased caecum fermentation parameters in broilers Increased concentration of total SCFA and acetic acid	Mašek et al. (2014)
450 mg/kg	Reduced drip loss and Ph in the pectoral muscle after slaughter at 45 min Increased antioxidant capacity of pectoral muscle Increased expression of level of myosin heavy chain MyCHI and MyCHII α	Xiong et al. (2024)
100 mg/kg	Increased mass of chest muscle Reduced Jejunal Crypt depth Increased villus width	İşgör et al. (2023)

MDA, malondialdehyde; DPPH, 2,2-diphenyl-1-picrylhydrazyl; TBARS, thio barbituric acid reactive substances; SCFA, short-chain fatty acids.

TABLE 5 Effects of ferulic acid inclusion in broiler chickens' diets on performance and meat quality.

Ferulic acid dose	Effect	References
300 mg/kg ferulic acid	Improved ADG and FCR in broilers; enhanced antioxidant enzyme activity (SOD, CAT, GSH-Px) in plasma and breast muscle; reduced MDA concentration	Yi et al. (2025)
250 and 500 mg/kg ferulic acid	Reduced lipid peroxidation (TBARS) in stored breast meat; improved oxidative stability and sensory attributes (flavour, juiciness) post-slaughter	Bou et al. (2009)
300 mg/kg ferulic acid	Increased villus height: crypt depth ratio in jejunum; enhanced intestinal microbiota balance; reduced <i>Campylobacter</i> spp. Colonisation; improved nutrient digestibility	Shu et al. (2022)
200 and 400 mg/kg ferulic acid	Improved drip loss, pH stability post-mortem, and meat colour (L^* , a^* , b^*) in pectoral muscle; reduced incidence of pale, soft, and exudative (PSE) meat	Zhang et al. (2025)
200 mg/kg ferulic acid (feedlot steers; for References)	Improved meat quality scores: tenderness, WHC, and shelf life in stored meat; elevated antioxidant capacity of muscle tissue	Gonzalez-Rios et al. (2016)
300 mg/kg ferulic acid	Attenuated LPS-induced hepatic injury; downregulated pro-inflammatory cytokines (IL-1 β , TNF- α); upregulated anti-inflammatory IL-10 expression	Shu et al. (2022)

TBARS, thio barbituric acid reactive substances; MDA, malondialdehyde; WHC, water-holding capacity; PSE, pale, soft, exudative; SOD, superoxide dismutase; GSH-PPX, glutathione peroxidase; LPS, lipopolysaccharide.

itself. Incorporating polyphenolic-rich compounds has been associated with an improved fatty acid (FA) composition in the meat, including increased levels of monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), while also reducing saturated fatty acids (SFA) (Salim et al., 2018). This is particularly important since consumers increasingly seek meat products with better health benefits. The inclusion of phytochemicals in poultry diets can significantly affect meat organoleptic traits, including taste, aroma, and texture, attributes that are essential for consumer acceptance. For instance, certain herbal supplements have been linked to enhanced flavour profiles and overall sensory qualities of the meat (Pelicano et al., 2005; Bogatko et al., 2024). Such improvements can appeal to consumer preferences, potentially leading to better market outcomes for poultry producers.

3.1.8 Trans-pinocarveol s and its potential effect on broiler performance

Trans-pinocarveol, a bicyclic monoterpene with notable biological properties, has shown to possess antimicrobial and antioxidant effects that could be advantageous in enhancing poultry production parameters (Kostadinović et al., 2015; Zachariah and Leela, 2018). Research indicates that the inclusion of essential oils and phytochemicals, like trans-pinocarveol, in poultry diets can potentially improve growth performance metrics such as body weight gain and feed conversion efficiency (Rafeeq et al., 2022). Monoterpenes, positively influence gut health and promote microbial balance, thereby enhancing nutrient absorption and utilization (Zungu et al., 2023). Consequently, this could alleviate the negative impacts of environmental stresses, such as heat, which is known to impair both growth performance and overall meat quality in broilers (Lu et al., 2017). The addition of phytochemicals can significantly modify carcass characteristics. Specifically, compounds such as trans-pinocarveol may reduce oxidative stress in muscle tissues, which is essential in preventing lipid peroxidation that detrimentally affects meat quality

indicators like tenderness, juiciness, and flavour (Mierliță, 2015). Studies have suggested that the inclusion of dietary antioxidants improves the oxidative stability of meat products, potentially extending shelf life and enhancing sensory qualities, which are critical for consumer acceptance (Gaya et al., 2011). Furthermore, the application of trans-pinocarveol might also influence the fatty acid profile of the meat. Research shows that specific phytochemicals can alter the deposition of fatty acids in meat, promoting a healthier lipid composition by increasing unsaturated fatty acids and decreasing saturated fatty acids, thus improving the nutritional profile of poultry meat (Ponte et al., 2008). This alteration in lipid composition enhances health benefits and supports consumer preferences for meat products with lower saturated fat content. Moreover, trans-pinocarveol's efficacy may relate to its potential in modulating the physiological responses of broilers under stress conditions. In scenarios of chronic heat stress, the antioxidant properties of trans-pinocarveol can mitigate oxidative damage, maintain muscle integrity, and minimize adverse effects on meat quality. Studies indicate that the antioxidant potential of similar phytochemicals may help maintain higher pH values post-mortem, which is crucial for improving meat tenderness and overall quality (Attia et al., 2010). The incorporation of trans-pinocarveol from *M. flabellifolius* in broiler diets has the potential to enhance both performance and meat quality through improved growth metrics, modulation of oxidative stress, beneficial alterations to fatty acid profiles, and better management of stress-related physiological challenges.

3.1.9 Quercetin glucoside and its potential effect on broiler performance

The nutritional enhancement of broiler diets with quercetin glucoside which is also abundant in *M. flabellifolius* has been shown to positively influence growth, performance and meat quality in poultry. Quercetin, a flavonoid recognized for its antioxidant properties, plays a crucial role in poultry nutrition by reducing

TABLE 6 Effects of quercetin and quercetin glucoside inclusion in broiler chickens' diets on performance and meat quality.

Quercetin dose	Effect	References
0.5 g/kg quercetin	Improved growth performance (BW, ADG); enhanced FCR; increased breast muscle yield; reduced abdominal fat deposition	Goliomytis et al. (2014)
0.5 g/kg quercetin	Improved oxidative stability of breast meat (reduced TBARS); maintained meat quality (pH, colour, WHC) during refrigerated storage	Goliomytis et al. (2014)
0.5 g/kg quercetin	Activated PI3K/PKB/AMPK signalling pathway; stimulated muscle protein synthesis; improved myofibre development and meat tenderness	Wang et al. (2022b)
0.5 g/kg quercetin	Increased inosinic acid (IMP) content in breast and thigh muscles; improved meat flavour profile and palatability scores in sensory evaluation	Wang et al. (2022b)
0.25 and 0.5 g/kg quercetin (methoxylated form)	Reduced lipid peroxidation and improved oxidative stability in thigh meat during cold storage (4 °C for 7 days); extended shelf life	Jang et al. (2011)
0.5 g/kg quercetin	Reduced drip loss and improved pH stability post-mortem; attenuated heat stress-induced oxidative damage to muscle tissue; improved meat succulence	Saeed et al. (2017)

BW, body weight; ADG, average daily gain; FCR, feed conversion ratio; TBARS, thiobarbituric acid reactive substances; WHC, water-holding capacity; IMP, inosine monophosphate (inosinic acid); PI3K/PKB/AMPK, phosphatidylinositol 3-kinase/protein kinase B/AMP-activated protein kinase signalling pathway.

stress and enhancing overall health, which is particularly relevant in raising broilers (Saeed et al., 2017). The mechanisms by which quercetin exert these benefits involve the activation of specific signaling pathways related to muscle metabolism. Quercetin supplementation activates the PI3K/PKB/AMPK signaling pathway, effectively stimulating muscle growth and improving metabolic responses (Wang M. et al., 2022). This reinforces the premise that dietary flavonoids can positively modulate physiological processes crucial for optimal broiler performance. Quercetin can improve the oxidative stability of meat, even under storage conditions that typically degrade quality (Goliomytis et al., 2014). Inclusion of quercetin in diets influences muscle tissue pH levels while decreasing drip loss, which is critical for maintaining meat quality and succulence. Their findings indicate a significant enhancement in the inosinic acid content, a key flavor component in both breast and thigh muscles when quercetin is included at appropriate levels, further supporting its inclusion in broiler diets for improved meat palatability (Wang M. et al., 2022). The potential of quercetin to enhance meat quality at-tributes during cold storage (Jang et al., 2011) and their research underscores the efficacy of quercetin in preserving meat quality over extended periods, likely due to its antioxidant properties that mitigate lipid peroxidation. Such effects can prolong meat-shelf-life while maintaining the sensory qualities essential for consumer satisfaction. Table 6 below summarizes the effects of quercetin and quercetin glucoside compounds inclusion in broiler chickens' diets on performance and meat quality.

3.2 Limitation and risks to application of *Myrothamnus flabellifolius* as a feed additive in broilers diets

Myrothamnus flabellifolius nutritional and chemical composition possesses a perceived potential to improve broiler pro-duction by improving growth performance, alter gut microbiome, morphology, reduce oxidative stress, and improve

meat nutritional and phytochemical parameters (Nantapo and Marume, 2022). However, the adoption and potential of *M. flabellifolius* plant and its extract as feed additives and alternative growth promoter in broiler diets can be affected by supply constraints, toxicity and bioavailability of phyto nutrients (Caceres et al., 2020; Nantapo and Marume, 2022; Pliego et al., 2022; Rehman et al., 2025). *In vivo* studies on the optimal dose are relevant and optimization of the inclusion levels to prevent negative effects due to compounds like quercetin that may inhibit mineral absorption and damage the gastro intestinal tract lining (Oteiza et al., 2018; Kmail, 2024) before they are asserted as feed additives. Many phytonutrients have low bioavailability and are rapidly eliminated in the broiler gut, hence need strategies, for example, microencapsulation or microbial fermentation aimed at improving the bioavailability of phyto nutrients and their efficacy (Obianwuna et al., 2024; Oni and Oke, 2025).

3.3 Conclusion and future perspectives

Myrothamnus flabellifolius, often referred to as the resurrection plant, possesses a remarkable phytochemical and nutritional profile that could potentially benefit broiler health, performance and meat quality. The plant is rich in various bioactive compounds, including essential oils, flavonoids, and terpenoids, which exhibit diverse pharmacological properties (Nantapo and Marume, 2022). The nutritional aspects of *M. flabellifolius* include a substantial array of essential nutrients, with emphasis on its capacity to act as a functional feed additive in poultry diets. While specific detailed studies on the direct nutritional composition of *M. flabellifolius* are limited, its categorization as a source of various phytochemicals suggests that it may contribute essential vitamins, minerals, and bioactive compounds that can affect overall poultry health and productivity (Nantapo and Marume, 2022). Primary phytochemicals in *M. flabellifolius* have been documented for their antimicrobial properties, providing defense against various

pathogens (Sharifi-Rad et al., 2015; Matotoka and Masoko, 2024). The presence of these bioactive compounds not only potentially contributes to the reduction of microbial load in the gut but also might fortify the immune system of broilers. The essential oil exhibits of *M. flabellifolius* have a significant antioxidant activity, which can potentially mitigate oxidative stress resulting from environmental challenges such as heat stress. These antioxidant properties can prevent oxidative damage to muscle tissues, thereby enhancing meat quality and preserving sensory characteristics (Chukwuma et al., 2019; Nantapo and Marume, 2022). The nutritional and phytochemical properties of *M. flabellifolius* potentially provide significant opportunities for improving broiler health and performance. Through mechanisms such as antioxidation, antimicrobial action, and immunomodulation, this plant can serve as a potential functional feed additive. However, there is need to carry out *in vivo* studies to test its potential effect on broiler chickens and continued research in optimizing its use in poultry nutrition to enhance production efficiency and meat quality. Future studies should specifically determine the optimal dietary inclusion level of *M. flabellifolius* extract in broiler diets across distinct production phases (starter, grower, finisher); evaluate its effects on specific growth performance parameters (FCR, ADG, body weight gain) and meat quality attributes (pH, WHC, oxidative stability, sensory evaluation) under standardised conditions; assess gut microbiota modulation using 16S rRNA sequencing to characterise the prebiotic potential of the plant's carbohydrate fraction; investigate potential toxicological effects, particularly related to the quercetin content, which has been associated with inhibition of mineral absorption at high doses (Oteiza et al., 2018); and evaluate bioavailability enhancement strategies such as microencapsulation or microbial fermentation to improve the efficacy of phytonutrient delivery (Obianwuna et al., 2024).

Author contributions

RN: Conceptualization, Funding acquisition, Methodology, Validation, Visualization, Writing – original draft, Writing – review and editing. JB: Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review and editing.

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